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Outlook for Technology and Labor in Telephone Communications

U.S. Department of Labor
Bureau of Labor Statistics
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Outlook for Technology and Labor in Telephone Communications

U.S. Department of Labor
Elizabeth Dole, Secretary

Bureau of Labor Statistics
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July 1990

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Preface

This bulletin appraises some of the major technological changes emerging in telephone communications (SIC 481) and discusses the impact of these changes on productivity and labor over the next 5 to 10 years.

This publication is one of a series which presents the results of the Bureau's continuing research on productivity and technological developments in major industries. Previous bulletins in this series are included in the list of BLS publications on technological change at the end of this bulletin.

The bulletin was prepared in the Bureau's Office of Productivity and Technology, Edwin R. Dean, Associate Commissioner, under the direction of Charles W. Ardolini, Chief, Division of Industry Productivity and Technology Studies. The report was written by William V. McMichael. Robert Ball and Richard W. Riche supervised its preparation.

The Bureau wishes to thank the C & P Telephone Company for providing the photographs used in this study.

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Summary

Technological innovations associated with telephone communications are being applied to a broad range of operations, and employment, productivity, and skill requirements are affected by their diffusion. Fiber optic cable networks, digital switching systems, digital transmission, advanced office automation, and satellite communications are among the major innovations gaining prominence.

New technology and deregulation are changing the telephone communications system from a predominantly voice network to a system that accommodates data and video transmission as well. These changes have led to a growing expansion in the variety of telecommunications goods and services. Government agencies and private firms are using new technology to develop telephone communications systems tailored to their needs. These proprietary systems often bypass the traditional public network.

Productivity in the telephone communications industry (SIC 481) is increasing at a high annual rate, and new technology has been a major contributor to this growth. Between 1967 and 1988, output per employee hour increased at an annual rate of 5.9 percent, well above the 1.1–percent annual rate for the nonfarm business sector, and among the highest rates of increase recorded by a service sector industry for which BLS publishes measures. The growth rate over this span of two decades averaged 4.3 percent between 1967–73, rose to 7.2 percent between 1973–79, and slowed to a gain of 5.2 percent during 1979–88.

Employment in the telephone communications industry has been declining. In 1988, a total of 897,500 employees were working in the industry, well below the 1.1 million in 1981, the peak employment year. Women constitute a significant (slightly under 50 percent) but declining proportion of the work force.

The structure and content of occupations also are undergoing change. Telephone operators, office accounting and clerical workers, and installers and repairers are among occupational groups declining in number or experiencing slow growth as fiber optic systems, electronic switching, office automation, and other technologies discussed in this report are diffused more broadly. In contrast, employment in computer–related occupations and in electrical and electronic engineering positions is expected to increase. The content of jobs also is being modified by technological change, and some employees are undergoing training to acquire new skills. Telephone communication is increasingly competitive domestically and worldwide, and the industry is among the leaders in spending for new plant and equipment. Capital spending per employee in telephone communications is among the highest for all industries including manufacturing. In 1987, capital outlays totaled about $24 billion, and substantial spending will continue in the 1990's as modern equipment is diffused more widely. Expenditures for research and development in the telephone and telegraph equipment industry (SIC 3661)—the supplier of new technologies—also are expected to continue at high levels.

Adjustment to technological and related changes that lower employment and change job skills encompasses a series of steps, including advance notice of impending changes, early assessment of required revisions in staff, training programs, and severance pay and job search assistance for workers on layoff. Telephone companies and the Communications Workers of America (CWA) and other unions are working together to develop innovative steps to mitigate the adverse impact of change. Special technological change committees are in place to explore issues and to implement joint training programs and other techniques for adjustment. Approximately 55 percent of the industry work force is covered under collective bargaining agreements which contain provisions related to seniority, wages, layoff and recall, and other measures applicable during periods of retrenchment.

Industry Structure

The 1980's have brought substantial technological and structural change to the telephone communications industry. The divestiture and reorganization of the American Telephone and Telegraph Company (AT&T) in 1984 has been the most significant change. New technology and regulatory freedom have spurred the transition of the industry from a basic voice and message communication complex to an expanded, more competitive network offering a variety of new or improved services. Innovations in computer technology facilitate the merger of telecommunication and data processing capabilities.

Seven large regional companies, a major separate long–distance company that handles 70 percent of intercity calls, several other long–distance providers, and more than 1,000 local, independent companies make up the telecommunications network. Prior to 1984, AT&T (Bell System) served most urban areas and dominated the industry with more than 80 percent of total telephones and operating revenues. Moreover, it provided almost all long–distance service and manufactured telephone equipment at its Western Electric subsidiary.

The telephone communications system is a public and private network that links voice, text, data, and video transmission. Voice communication accounts for about 85 percent of all traffic on the public network, but data and other non–voice transmissions are growing rapidly. The average person makes 900 calls a year, 60 percent of them during business hours. The system contains more than 20,000 switching offices and 128 million access lines; about 3 out of 4 access lines are connected to residential customers. Almost 900,000 workers operate and maintain the vast and complex network.

Technology in the 1990's

Substantial investments are being made by the telephone communications industry in new technology to expand and improve the Nation's communications network. Fiber optic cables, digital transmission, operations support computers, and advanced switching systems are among the core changes that increase productivity and quality. Increasingly, private firms and government agencies are developing their own communications systems that connect with or bypass public telephone companies. The diffusion of technological change in the telephone communications industry during the 1990's will continue to be affected by regulatory decisions of the Federal Communications Commission, State public utility commissions, and judicial decrees related to the divestiture of AT&T and control of new services, as well as by economic and market factors.

In this section and in table 1, major innovations in telephone communication and their impact on employment and productivity are described. Prospects for diffusion in the 1990's also are examined.

Fiber optic cables

Fiber optic cables that use high–speed pulses of light to transmit voice and data are of growing importance. These compact and lightweight cables are made of small diameter glass fibers that offer expanded transmission capacity and longer service life when compared to copper cable systems. These cables offer their greatest potential benefits to transmissions in digital formats, but they can also be used in analog formats. AM (amplitude modulation) and FM (frequency modulation) are analog radio signaling formats that are benefiting from the use of fiber optic cables.

Fiber optics have brought a revolution to telephone communications technology.

The introduction of fiber optic cables is having a significant impact on employment—particularly in labor–intensive maintenance and installation activities. High–capacity fiber optic cables lower labor requirements per volume of transmission and are a major factor in the projected decline in the number of installers and repairers by the year 2000. Fiber optic networks are complex; they require new skills, new procedures, and new instruments to install, test, and maintain them.

Diffusion of fiber optic networks for local and long distance telephone communication is proceeding at a fast pace. The first U.S. transcontinental and undersea fiber optic cables to Europe recently were put in place. By the year 2000, a majority of high–volume domestic telephone transmissions and a large portion of international calls will be over optic cables using laser methods of light transmission.

New methods are being developed to manufacture and

Table 1. Major technology changes in the telephone communications industry

Technology	Description	Labor implications	Diffusion
Fiber optic cable	Fiber optic cables use highspeed pulses of light rather than electricity to greatly expand call–handling capacity. This technology combines glass fiber cables with light sources for high capacity transmission. Cables are compact, resist electrical interference, and interface with digital switching and transmission techniques. Fiber optic cables are used for both long–distance and local interchange routes.	High–capacity and reliable fiber optic transmission systems buried underground significantly lower labor requirements for installation and repair workers per unit of system transmission. However, reduced demand for employees in these occupations will be mitigated during 1990–95 because of the replacement of copper wire systems by fiber optics.	Diffusion is rapid among both long–distance and local companies. By the year 2000, most high volume telephone transmission will be via fiber, but a variety of transmitting media will continue to be used. Many telephone calls will be transmitted through a combination of wires, microwaves, and optic fibers. The first transcontinental U.S. and undersea fiber optic cables to Europe were put in service recently.
Advanced, digital versions of electronic switching systems (ESS)	Very high–speed computer–based switching equipment monitors its own performance and provides advanced dialing capabilities. Call–handling capacities greatly increased over previous equipment.	Substantially decreases work for central office equipment installers and repairers. Modular design and self–maintenance features reduce routine maintenance. However, a knowledge of computer systems and programming concepts is necessary for employment involving digital switching technology.	By the year 2000, ESS will service more than 95 percent of all telephones; ESS now services over 60 percent of all telephones.
Private branch exchanges (PBX)	PBX's with advanced features are being installed by firms for internal call switching and for connection with outside lines. PBX systems also connect with long–distance companies by wire, cable, or microwave. Digital technology has expanded the ranges of services that PBX hardware and software can provide, and system costs are falling.	Reduces demand for installers, repairers, and other staff in telephone companies, but raises demand for these occupations in private firms that provide their own PBX services. The net number of jobs should still be less than in the past.	The number of PBX systems is expected to increase as their cost declines and performance is enhanced. New software makes investment in modern PBX's attractive for smaller firms. The pace of diffusion will be affected by developments in centrex, T–1, and related technologies.
Digital transmission	Transmission of digital electrical pulses instead of continuous analog signals greatly increases the capacity of the telephone network. Digital transmission is compatible with many technologies. Pulse Code Modulation (PCM) is the most widely used system for digital transmission. The implementation of Integrated Services Digital Network (ISDN) is expanding the scope of digital transmission.	Digital transmission increases system capacity without requiring additional labor, but gains in service demand may moderate the negative impact on employment. Digital transmission reduces unit labor requirements in line and cable crafts, but increase demand for central office installation staff. Employment of engineers may expand as digital transmission extends the scope and technical capability of the system.	Conversion to digital transmission is accelerating. By the year 2000, nearly all of the telephone network transmission is expected to be digital compared to under 50 percent in 1989. Conversion to digital transmission for long–line service is proceeding at an even faster pace with nearly complete conversion anticipated in 1990. Digital transmission for residential and small business applications is commonplace, and digital transmission in rural areas is expanding.
Computer applications	Computer technology is vital to the telephone communication industry, and applications are pervasive and growing. Computers automate office data processing functions (see discussion on office automation in this table), design and manage the traffic network, monitor and improve quality control, perform traffic and market analysis, switch and bill operator assisted calls, diagnose systems problems, and perform related tasks. Operations support computers perform remote and automated testing, aid service installation, and do many work operations with little human involvement.	Computers lower unit labor requirements, automate major duties in selected occupations, and alter the mix of job skills and responsibilities. Major occupations affected by computerization include supervisors and managers, operators, clerical and related workers, installers, maintenance workers, testers, engineers, and central office technicians.	The diffusion of expensive and advanced computer networks has been most rapid in the larger telephone companies. The pace of change has been slower in the small independents that serve a few hundred to a few thousand lines, because the capital investment relative to employment and the customer–base usually is quite large. However, small companies are using personal computers for accounting and billing. Small companies with the means are adapting computer technology as rapidly as the larger firms. Computerized testing and monitoring systems are diffusing similarly.

Table 1. Major technology changes in the telephone communications industry - Continued

Technology	Description	Labor implications	Diffusion
Office automation	Office automation systems are being improved and extended to a greater range of functions. They consist of a mix of computer and related technologies to increase productivity including work stations incorporating advanced personal computers, improved software for accounting, word processing, graphics, specialized instruction and related tasks, and automated telephone systems. Some office computer systems have network capability with data, memos, and other documents transmitted between work stations, printed at remote locations, and copied and integrated into other systems through the use of FAX, electronic mail, etc. Moreover, networks have the capability for online, two–way communication via PC's or terminals.	Labor requirements for clerical and secretarial work and selected management and accounting activities are being reduced. Record management also is being simplified and made more efficient. Job content is changing as managers use PC's and networks to manage data. Professional workers are using word processing integrated with data bases, spreadsheets, graphics, and other software to achieve productivity gains. Moreover, office automation has eliminated entire layers of management in some telephone companies, with significant labor savings and other economies reported.	Telephone companies are adopting advanced office automation systems at a relatively fast pace. Although data on the total number of PC's and work stations installed at the industry level are not available, some industry experts assert that the pace of change is accelerating in response to competitive pressures to lower costs. Office automation appears to be proceeding faster in the larger firms.
Satellite communication	Satellites equipped with transponders receive voice, data, and television signals and relay them back to facilities located throughout the world. Satellite systems provide supplemental capacity and versatility to the existing network. These systems primarily are used for international communication, although satellite transmission for domestic use is increasing.	Expansion of satellite communication is expected to require a moderate increase in employment of engineers and physicists engaged in R & D, and those involved in the construction, operation, and maintenance of earth stations. Those employees in conventional ground–based facilities will continue to be largely unaffected. Maintenance labor requirements on satellite systems have declined as the durability and reliability of satellite transmission technology has improved.	U.S. firms are substantially involved in satellite communication with 30 satellites in orbit in 1988. Fifteen satellite launchings are planned through 1990. By the end of 1990, about 2,000 transponders are expected to be in orbit, of which nearly one half will be U.S. owned. During the 1990's, satellite communication both world–wide and domestic is expected to increase even though competition for fiber optic cables will intensify.
Cellular telephone technology	Cellular systems divide cities and other service areas into regions called cells. Each area is served by a low power radio transmitter. Mobile calls are automatically transferred from cell to cell as users travel.	Because an expansion phase is underway, demand is growing for construction and installation work. These systems are employing increasing numbers of installers, maintenance personnel, managers, and office workers with the special skills required by this technology.	By 1990, equipment sales reached $3 billion a year and there were over 3 million subscribers in 300 metropolitan areas. Cellular telephones should serve 20 million subscribers and cover all U.S. urban areas by the end of the century.

coat fiber optic cables to improve data transmission, speed, and accuracy. Uniform standards for fiber optic cable diameter, refractive qualities, and protective coatings should further spur their rate of adoption. These standards are referred to by the industry as a "protocol." In 1989, the fiber protocol was issued which recommended the use of 62.5/125 micromillimeter multimode fiber, which will allow transmission at 100 megabytes per second compared to current transmission rates of under 10 megabytes per second. Manufacturers are already producing some equipment to support this protocol. These standards will be for most business uses. In telecommunications, more powerful single–mode fibers that use laser light sources, rather than light–emitting diodes, will more generally be used. These laser driven systems provide an extremely broad transmission bandwidth, and this means greater data–carrying capacity and flexibility.

A new techique has led to the development of chips containing 2 million lasers in the space of a fingernail. This development should lead to greater refinement of light wave technology and to the manufacture of microscopically thin glass fibers to connect to these lasers. The potential capacity of laser–based telecommunications and computer applications is virtually unlimited.[1]

A major problem in the development of fiber systems has been the difficulty of splicing fibers. As the potential

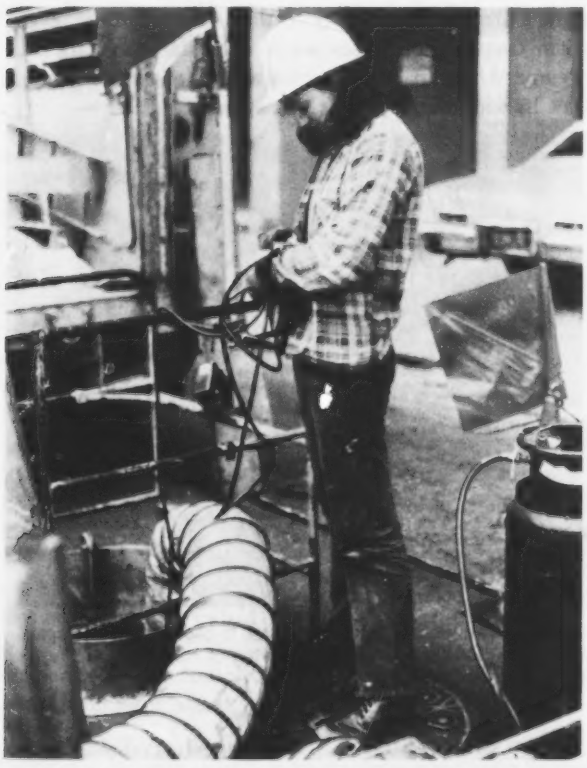
[1] William Booth, "Tiny, Powerful Laser Created," *The Washington Post*, July 31, 1989, section 1, p. 2.

speed and bandwith of fiber systems has increased, the tolerance for signal degradation at connection points has diminished. Joining cables is done by heat fusion, or aligning precisely cut fibers and bonding the ends with gels and epoxies that share the same light refraction properties. Fusion splices can be tested and optimized by microprocessors in the aligning and splicing tools. The results of these advances are a reduced need for fiber splicers

Light wave systems require little maintenance and they increase system capacity. Less labor is needed to maintain and alter transmission networks. Declining demand for line workers and other maintenance personnel will occur slowly, because the existing, aging wire networks require increasing maintenance, and the ongoing conversion to fiber optic networks makes use of many installers.

Digital switching systems and private branch exchanges

Digital switching systems, the most recent version of electronic switching, use computers and software to switch a growing volume of telephone calls. Although older switching systems are still in use, they are being displaced by advanced systems that feature high speeds, high reliability, and ease of maintenance. These systems sharply increase switching capacity and lower unit labor requirements for central office, and installation and maintenance workers.



Hand-held splicing equipment makes on-site work more accurate and efficient.

The replacement of wholly mechanical switching by various stored program control and electromechanical relays began in 1963, but fully digital, non-electromechanical switching dates from the mid-1970's. A version of common channel signaling (SS7) that uses newer, digital switching technology provides a more efficient way to handle interoffice signaling. Systems such as SS7 can allow customers to identify an incoming call's phone number, block calls from certain numbers, make automatic return calls to missed calls, or forward calls to another number. These systems work well with integrated digital services, three-way calling, voice mail, and call waiting.

Digital switching technology often uses techniques that connect to transmission facilities without elaborate interfaces. Coded signals are switched automatically using technology related to computer memory storage.

Although switching systems have been automated for decades, digital switching achieves most changes through programming, unlike older model switching systems that required complex wiring modifications as alterations were needed. The skills involved also are quite different. The newer systems require much less physical maintenance. Digital switching systems are compact and contain modular components. The reliable, solid-state technology used in modern switching is virtually free of moving parts. Installation labor requirements, thus, are lower.

Digital switching systems will be expanded at a relatively rapid pace over the next decade. In 1989, analog or digital electronic switching systems (ESS) were available for over 60 percent of all telephones, with the larger companies having them available for over 80 percent of telephone lines. By the year 2000, electronic switching is expected to be extended to 95 percent of the telephones in service, as modern central offices are constructed and older, electromechanical switching systems are phased out.

The installation of private branch exchanges (PBX) by a growing number of firms is having an adverse effect on employment of installers, maintenance workers, Centrex workers, and other staff in telephone companies. However, the increasing use of PBX is expanding employment opportunities for such workers outside of these companies. PBX systems carry out internal company call switching and connections to outside lines. PBX systems also connect directly to long-distance companies by wire, cable, or microwave link. This saves the company leased-line fees and call fees, and the connection charges typically paid to local telephone companies. Both small and large PBX systems are available to handle the thousands of connections required by businesses. Some systems cost $350,000 or more, but digital technology, modular formats, and new software can provide services to companies with fewer than 250 phone lines at an economical rate. Technological improvements and lower costs per line are the reasons that PBX systems have grown rapidly in recent years.

Centrex services offered by local companies and long-distance carriers offer alternatives to PBX, while one form of high-speed digital transmission (T-1) technology offers enhancements that make PBX systems and Centrex services even more cost effective. Centrex technology is competing with PBX technology by offering services such as call forwarding, speed calling, and automatic route select, and both systems are making rapid advances. T-1 services feature high-speed digital transmission (most commonly at 1.544 megabytes per second—which is also the basic international standard for a form of digital transmission discussed in the next section). T-1 has the capability for 24 simultaneous voice transmissions over facilities that typically served a single transmission, a twelvefold increase over a wire pair's analog transmission of a single, two-way conversation. Capacity can be allocated to combinations of voice, video, and facsimile transmission (a process that is sometimes referred to as "facility integration"). T-1 is well suited for volume calling by large firms and can be channeled by the customer into private networks using leased T-1 lines. There are over 50,000 existing T-1 transmission systems. Other systems that expand capacity, such as T-3, a faster system, (45 megabytes per second) are also in use.

Portable equipment refinements speed repairs and alterations at customer premises and at remote sites.

Digital Transmission

Digital transmission converts continuous analog signals to digital electronic pulses to greatly increase the speed, capacity, and versatility of telephone communication. The U.S. telephone network is projected to be nearly completely digital by the year 2000, compared to less than 50 percent in 1989.[2] Digital transmission over optical fiber cable networks will greatly improve quality and lower labor requirements per unit of transmission volume.

Digital telephone transmission systems that accommodate voice, data, and video transmissions differ markedly from analog systems. Conventional telephone transmission involves a continuous, wave-patterned signal source on a single communication channel. In contrast, digital transmission converts analog signals into electronic pulses, and reconverts them to analog form upon reception.

To accomplish these steps, digital systems compress human speech and data into tiny pulses for transmission. The spoken word is reduced to a digital code that is transmitted at great speed. This pulse of data and those from hundreds of other conversations and data sources can be transmitted simultaneously, so a transmission path is not monopolized by a single conversation. The pulses include identifiers that sort out and route combinations of words and other data to those designated to receive the information. Digital coding insures that reproduced signals are equal in quality to the source material, even when transmission losses occur. Transmission data are organized into "packets," which are sorted in their traffic flow by sophisticated switching systems.

Central office switching systems continue to become more complex, which contributes to the demanding nature of installation and repair work.

[2] 1990 U.S. Industrial Outlook, U.S. Department of Commerce, International Trade Administration, p. 32-5

The implementation of Integrated Services Digital Network (ISDN) is expected to improve and expand the scope of digital transmission, and spur diffusion of electronic technologies in homes and offices. The customer hardware in ISDN systems consist of integrated voice and data terminals that rival the complexity and versatility of personal computers. For example, digital transmission over a single optical fiber can accommodate voice, data, text, and video transmission and make possible multiple applications such as a complex of phone lines, cable TV, home and office security systems, video conferencing, and other innovations. ISDN systems are expensive, however, and their rate of adoption will depend on the availability of resources and the status of legislation related to the type of data that can be provided by telephone companies. ISDN capability for commercial applications was introduced in 1988, and broader diffusion is anticipated in the early 1990's. Most future systems and standards will be developed in a process of international cooperation.

Several developments that may affect the future of ISDN are underway. Telephone companies are expected to introduce fiber optic cable systems from central offices to residential subscribers which will make available ISDN services such as video teleconferencing and high definition TV (HDTV) to residential subscribers. Another development is the growth in the number of equipment manufacturers willing to meet and develop markets for ISDN equipment and standard interfaces. A third development is Broadband–ISDN (B-ISDN), which can transmit at 150 megabits per second.[3]

Computer applications

The telephone communications industry is among the leaders in applying computer technology to office and operating functions. Computers are the core technology that makes possible electronic switching, digital transmission, satellite communications, and other major innovations discussed in this bulletin. The vital importance of the Nation's telephone network is reflected by the substantial investment of funds and technical staff in research and development related to computer applications and networking.

In the offices of telephone companies, more sophisticated computer systems increasingly are being used for administrative, billing, and accounting and financial functions. Consequently, unit labor requirements for clerical and related staff continue to be reduced significantly. As an example, computers record key data related to telephone call accounting, including the originating number and number called, the duration of the call, and the billing amount and period. These data can be incorporated into a completely integrated accounting and management information system. Computers also forecast volume of demand and perform market analysis. Local area networks (LAN) using personal computers have brought powerful systems to the desks of many office workers. To some extent, telephone companies have been attempting to perform many activities such as forecasting peak demand automatically for decades, but the power of new computing equipment has allowed a vast expansion of the scope of these automatic systems and the integration of the data produced and processed. A broader overview of developments in office automation is presented in the next section.

Computers and related equipment are automating and changing the job requirements of operators. Computers intercept calls to nonworking numbers and provide recorded responses, handle switching and billing on operator–assisted long–distance calls, monitor and compute charges from pay phones, aid operators in handling directory assistance calls, and perform related tasks. New technology has eliminated major duties performed by operators, and is a significant factor in the decline in employment in this occupation. However, computers have allowed operators to perform some new services and have greatly increased their productivity. The demand for the expanded services that operators are performing has created some new work and some new positions.

Computer technology that improves the maintenance and quality of network transmission is increasing productivity by lowering labor requirements of line and cable repairers, and office craft workers. Examples of these applications include the testing and analysis of problems related to signal loss and interference on transmission lines, the automation of testing of central office systems, and the introduction of new techniques to follow up on customer service problems. Other "operation support systems" provide customers with more services and allow customers to control many aspects of the day–to–day service operations. Service order processing and installation activities are supported by computers. Customer and premise records are maintained in data bases that are used to design the facility requirements and assign components to individual services.

Office automation

The office environment in the telephone communications industry continues to undergo significant technological change. The techniques being applied to office tasks are extensive. They include word processing technology that replaces conventional typewriters; automated communications equipment in place of manned switchboards; diskette, tape, or hard disk filing systems as a substitute for paper documents; personal computers with spread sheets, automated accounting systems, computer graphics, terminal emulation, and instruction systems that replace manual methods; messaging systems in place of paper memos and letters, and the extensive use of electronic

[3] *1989 U.S. Industrial Outlook*, U.S. Department of Commerce, International Trade Administration, p. 29–2.

support equipment including photocopiers, automated labelers, collators, printers, and related technologies.

Advanced office automation systems incorporate work stations that centralize access to automated office equipment and software. Work stations usually are interconnected and share printers, plotters, data storage systems, and other equipment. These connections sometimes extend to remote sites in other cities in the United States, or in other countries.

Messaging systems include facsimile transmission (FAX), voice mail, electronic mail (used in computer networking), and customer services comparable to those provided by answering machines. As FAX costs have dropped, this technology has become widespread in business and is entering the home marketplace. FAX transmission growth is increasing the demand for telephone services.

In the coming decade, office automation will be able to make use of voice recognition technology. Voice recognition will allow telephone numbers to be dialed by voice command. Enhanced voice transmission technology will permit systems to respond only to authorized voices. This would limit message recording and receiving to individuals registered in the system.

In general, automated systems increase productivity in record keeping and retrieval. Computer data base systems edit and combine records for diverse purposes, and writing and graphics preparation in modern offices require far less labor than the manual methods they replace. Modern data bases are more readily available and compiled in a manner that helps managers make effective decisions.

Automated equipment simplifies operator assistance, call management, and customer billing.

Office automation is having a significant impact on employment and skill requirements in several major operations. BLS projections to the year 2000 anticipate lower employment levels for selected clerical staff. New technology facilitates the consolidation of separate administrative levels and provides capabilities to monitor employee output and to obtain other data useful for improving productivity.

Satellite communications

Communication via satellite is an alternative to undersea cables for international signal transmission and is growing in importance. Furthermore, satellite communications make possible news broadcasting on location and communications to remote sites not served by cable or microwave systems. In operation, satellites are relay points for transmissions between distant earth stations, which in turn connect to the ground telephone network.

Substantial improvements in the capacity and performance of satellite systems have taken place since 1965, when satellite communication between the United States and Europe was initiated. Advances in semiconductor technology and micro–miniaturization of circuitry have enhanced the capacity, performance, and durability of satellite communication systems.

Performance of satellites has been improved in a number of important ways. The capacity and power of modern satellites greatly exceed those launched two decades ago, and their average lifespan exceeds 10 years—compared to only 18 months for early satellite systems. The more powerful transponders on satellites make possible the use of smaller and less expensive antenna systems on earth stations. Satellite communication systems also are being improved by compressing more signals into a transmission, and by adding multipoint transmission and reception to existing point–to–point service. Satellite transmission networks are expanding data and video capability along with voice communication service through fiber optic cable links to the earth stations.

To provide intercontinental service, most commercial satellites are in fixed–point locations over oceans. Positioning satellites over continental land masses is being evaluated; if proven feasible, the quality and flexibility of satellite communication and its importance to the domestic telephone network would be enhanced. Since 30 percent of existing transmission capacity in the 30 operating communications satellites is unused, this development seems likely.

Some labor involved in satellite communications is in the field of research and development. Personnel also are needed to construct, operate, and maintain supporting ground stations. Three new ground stations and 15 satellites are planned by the end of 1990.

Cellular technology

Cellular service is a mobile communications technology growing in popularity. Cellular systems divide cities into compact geographic areas or cells, each served by a low power radio transmitter. As a caller enters and exits a service area, the call is transferred from one transmitter to another. Cellular systems connect to local and long–line

networks through central switching centers. In 1988, 420 systems served over 2 million subscribers—68 percent more than were served in 1987, but only six cellular companies accounted for more than half of all subscribers, and two of the six have a merger pending. The FCC allows each urban area to be served by two competing companies. Seventy–five percent of the population lives in areas providing cellular service. Within a decade, even most rural areas will be covered. Although relatively expensive, cellular technology combined with digital coding of transmission may someday open local phone markets to competition, since a "tetherless" telephone unit can transmit to competing cellular stations in the same area. In January 1989, the industry agreed to a rapid conversion from analog signaling to digital technology. The present analog systems are limited to serving no more than 1,500 users per square mile. The digital technology will allow as many as 35,000 users per square mile to be served. This will require smaller cell areas and some modest technological advances. The conversion timetable for digital transmission has been moved up 2 years, because some companies have capacity problems. Whether or not cellular technology ever becomes a completely competitive system, the convenience of accessing the telephone network while traveling or away from a wired instrument will continue to create strong demand.

The present cellular system may be joined by a European system called "Telepoint." This involves placing low–power transmitters in airports, train stations, shopping malls, and similar locations. Portable phone devices serve as home phone extensions. Calls are billed to home phones at lower rates than the charges levied for cellular service. Cellular systems are highly automated, but maintenance and administrative workers are needed. Employment is growing rapidly, and the digital conversion will sustain strong employment growth through the 1990's.[4]

Other technologies

In an industry as innovative as telephone communication, a substantial number of technological changes affect telephone communication services and the employees who provide them. It is appropriate to conclude this section by commenting briefly on several additional innovations that will be important during the 1990's.

Modular systems. As telephone communication equipment has become compact and more complex, repairs common in older systems are impractical. Much of the newer equipment is organized into "modules." These are assemblies of related parts encased as a single unit that easily connect or plug into a piece of equipment. When repairs are necessary, the defective module is unplugged, and a new one is plugged in. Often the module containing the defective component is identified by an automated system, relieving the technician of the job of locating the problem. Modular systems reduce the labor needed for repair and maintenance and modify skill requirements.

Systems engineering. The challenge of the 1990's is to simplify and expand connections to the telephone system so that firms providing a variety of services can make fuller use of the network. This is an extension of what has already taken place in long–line companies. A more competitive structure could allow the telephone network to grow and evolve, perhaps in ways that have not yet been imagined. Such developments could expand telephone employment, particularly in systems design and engineering.

Microwave transmission. Microwave transmission will continue to be an important communication medium. Used primarily for long–distance service, microwave transmission involves sending signals between towers via microwave. Microwave transmission is less expensive than stringing wire since the towers can be spaced many miles apart—5 to 18 miles is typical.

Microwave technology also aids diffusion of cellular phone systems. Microwave transmission links cellular stations while bypassing local telephone lines. Microwave towers allow the placement of some cells outside the telephone network, which is important in a mobile communication system and in remote rural homes.[5]

Common channel signaling (CCS). Common channel signaling uses computer software and compiler devices to merge information in analog and digital formats. This technology transforms telephone networks primarily designed for speech transmission to versatile systems that also transmit data and images. The U.S. version is called Common Channel Interoffice Signaling. CCS increases the capacity of telephone lines and reduces labor requirements of line maintenance and construction workers, partly by making the switching systems operate more efficiently. With this system, calls are not routed until a suitable pathway and free terminus are determined. Calls are not routed into busy tones. CCS has been around for decades, but newer switching systems, such as SS7, enhance the benefits this system provides to telephone companies. However, these systems are expensive. Equipping a large metropolitan area with SS7 costs over $40 million. Digital technology offers less costly methods to achieve even greater capacity and flexibility. Less complex, all–digital networks sharing common standards may be in place after the year 2000 in some parts of the world to transmit voice, data, and images. These systems will transmit at substantially higher speeds. They will need switches that operate at 1,000 times the speed of the best

[4] "Costly Wireless Telephone Greeted as a Bargain in Wide open Spaces," *The Washington Post*, November 11, 1986, p. D1.

[5] "Microwave Equipment Solves New Vector's Transmission Woes," *Telephony*, September 22, 1986, p.54..

that are presently in use. These networks will support broad–band ISDN and require less labor than existing telephone systems.[6]

Videotext. Providers of videotext services use telephone lines and modems to transmit written, graphic, and pictorial information to television sets or monitors. Generally, videotext capabilities are restricted to households and businesses with computers, but the number of these facilities is growing. Acceptance and use of remote data bases, advertising, news services, weather forecasts, financial information, airline schedules, public domain software services, and other data already are widespread. The use of telephone lines to transmit these services is a growing source of revenue for the telephone communications industry.

The scope and pace of market development of videotext services are slowly increasing. A firm in Boston is franchising its format and software to other companies, and in Houston, private firms are developing a greatly expanded range of videotext services.

The telephone communications industry is seeking to become active in the videotext market as a provider of services and as the billing agent for other videotext firms. Recent court decisions have lessened some restraints on the industry's involvement with videotext.

Messaging systems include FAX, voice mail, electronic mail (as used in computer networking), and phone company services that compare to those provided by answering machines. Because of the sharp drop in the cost of FAX, this technology has become widespread in business and is increasing the demand for telephone services.

Telephone companies are developing voice recognition systems that will allow oral instructions to be followed. This would mean a telephone number could be dialed vocally. Systems could be sophisticated enough to respond only to the proper voices, so that access to voice mail could be limited to the person authorized to receive the message. This technology should be commercially available within 5 years. It requires enhanced voice transmission, which is possible with various digital technologies.

Output and Productivity Trends

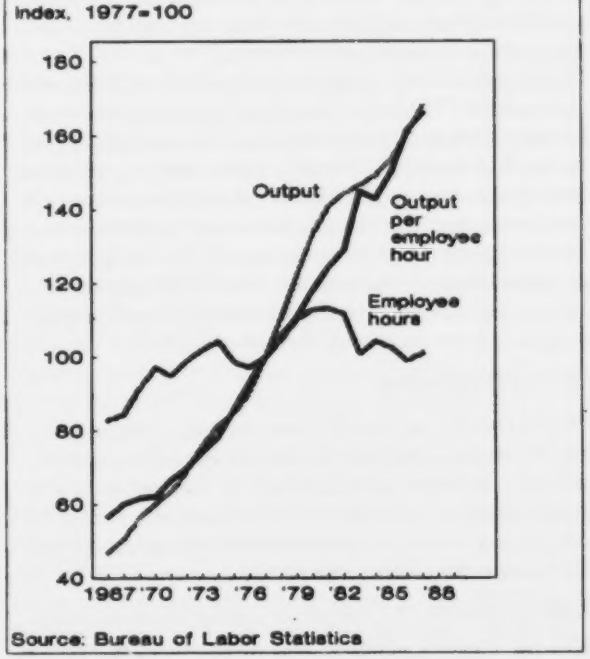
Output

Output in the telephone communications industry is increasing at a brisk pace, having risen at an annual rate of 6.7 percent between 1967 and 1988. This rate of growth is well above the rate in the nonfarm business sector, which was 2.8 percent over the same period. Moreover, output increased each year over this period, which reflects the importance of a telephone communications industry offering an array of services to a growing economy.

The rate of growth in output slowed during the 1980's compared to earlier periods. The annual growth rate was 8.0 percent between 1967 and 1973, remained essentially unchanged at 8.1 percent during 1973–79, but fell off sharply to 3.6 percent during 1979–88—a period which included the recession years 1981 and 1982 when output growth fell to 2.5 percent.

The outlook for telephone communications services is expected to be strong through the 1990's. Telephone companies increasingly are using a variety of technologies to expand the scope of their services, with revenues outside the conventional services accounting for a growing proportion of the total. Some firms market computer software, provide computer maintenance services, and engage in nontraditional enterprises such as real estate and publishing. According to one estimate, revenue from nontelephone call volume has been increasing at an annual rate three times greater than that from voice transmission related revenues.[7]

Chart 1. Output, output per employee hour, and employee hours in telephone communications, 1967–88



Source: Bureau of Labor Statistics

Productivity

Productivity in the telephone communications industry, as measured by output per employee hour, increased at a relatively high annual rate of 5.9 percent between 1967 and 1988. This rate of increase in productivity is higher than

[6] "Telecommunications Services," *1987 U.S. Industrial Outlook*, pp. 31–1 and 31–4.

[7] "Baby Bells Seek to Shed Regulatory Chains," *The Washington Post*, December 28, 1988, p. A6.

most of the other service sector industries for which BLS publishes measures, and is well above the 1.1–percent annual rate for the nonfarm business sector over the same period.

The rate of productivity growth varied within this period. Between 1967 and 1973, the growth rate was 4.3 percent per year, then rose sharply to 7.2 percent between 1973 and 1979, and slowed to an annual rate of gain of 5.2 percent over the more recent period, 1979 to 1988. Productivity in telephone communications also rose during the periods of recession in 1973–75 and 1981–82, at annual rates of 7.3 and 3.8 percent, respectively. Except for 1984, output per employee hour increased in every year between 1967 and 1988.

The productivity gains for the broad span 1967–88, and the interim and recession periods discussed above, reflected substantially higher annual rates of increase in output compared to employee hours. Between 1967–88, for example, output increased at an annual rate of 6.7 percent, compared to only a 0.8–percent annual gain in employee hours. As indicated earlier, the availability of an expanded communications network offering a wide array of new services in a setting of economic growth was a major spur to expansion.

Soldering skills are still necessary for line installers.

The extent to which productivity gains in the telephone communications industry can be attributed to advanced computer networks, electronic switching, and the other innovations discussed in this report cannot be determined precisely. It is important to keep in mind that the BLS productivity measure for this industry reflects the combined impact of technology, capital investment per worker, level of output, and the skills of management and the work force, to mention several factors. Nonetheless, new technologies in telephone communication lower unit labor requirements in diverse office and production tasks. Thus, there is widespread recognition that their impact on productivity and the level of employment can be substantial.

Capital expenditures

Telephone communications are increasingly competitive both domestically and in international markets, and the industry is spending billions of dollars annually to maintain a complex of modern plant and equipment. In 1988, capital expenditures were an estimated $24 billion. Telephone companies are accelerating the retirement of some categories of obsolete but still useful equipment and adopting newer technologies that have a substantial performance advantage and yield significant labor and other savings. AT&T, for example, wrote off $6.7 billion of older technology at the end of 1988 in accordance with plans to have an all digital public network in place by the end of 1990.

The industry is a leading innovator in the service sector, and its outlays greatly exceed capital spending per employee in most other industries, including manufacturing. In 1987, capital spending per employee was $48,900 in telephone communications, or over 15 times greater than the $3,100 per employee total in all manufacturing.

Modern technologies often are expensive. The installation of fiber optic networks alone is expected to approach $6 billion over the next 5 years, and outlays for satellite communication systems, conversion to digital transmission, and the further diffusion of other technologies highlighted in this report will require additional billions of dollars over the same period.

Research and development

The telephone communications industry also is among the industry leaders in funding R&D activities to assure that the communications network remains technologically advanced. A large share of R&D that affects the industry also is undertaken in the telephone and telegraph equipment industry (SIC 3661), which is not covered in this report. In 1988, about $5 billion was spent to develop new technologies and computer software that are expected to improve productivity and expand the quality and versatility of the telephone communications system. Higher levels of R&D funding were estimated for 1989. As an example, some equipment manufacturers are testing advanced multiplexing technologies that simultaneously transmit multiple voice and data channels over the same transmission line, which will lower costs for videotext, electronic mail, home banking, and other information services. Alternatively, the phone companies are developing broad–band multiplexing and improving their switching technologies for the same purposes. [8]

Employment and Occupational Trends

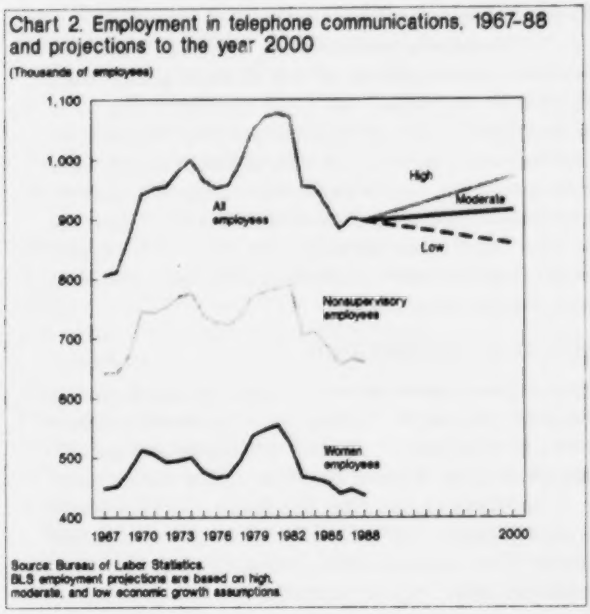
Employment

Employment in the telephone communications industry has been affected by automation, deregulation, and changing economic conditions. Over the period 1967–88, when productivity gains averaged nearly 6 percent a year,

[8] "Telecommunications Equipment," *1989 U.S. Industrial Outlook*, pp. 28–3 and 28–4.

employment increased by an annual rate of only 0.4 percent, with 806,500 workers employed in the industry in 1967 compared with 897,500 in 1988. The rate of employment change has varied significantly. Between 1967 and 1973, employment increased at an annual rate of 3.6 percent, slowed substantially during 1973–79 to an annual gain of only 0.6 percent, and declined during the more recent period, 1979–88, at an annual rate of 2.4 percent. The BLS moderate projection for employment in telephone communications in the year 2000 is 915,103, an annual average growth of only 0.2 percent.

Chart 2. Employment in telephone communications, 1967-88 and projections to the year 2000



Source: Bureau of Labor Statistics.
BLS employment projections are based on high, moderate, and low economic growth assumptions.

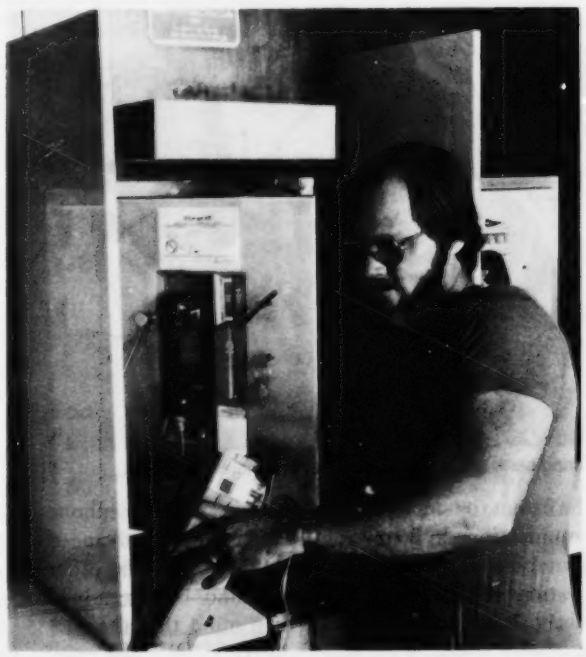
The fall-off in employment has been particularly marked since 1981, when 1,077,300 workers were employed in the industry—a record high. Over the 7-year period 1981–88, employment dropped by 179,800 workers, an annual rate of decline of 2.8 percent.

Women constitute a major but declining proportion of total employment in the telephone communications industry. In 1988, just under half the work force was female, compared to 56 percent in 1967. Over this period, male employees increased by about 28 percent, while the number of women dropped slightly. In the telephone communications industry, large numbers of women are employed as operators and in office accounting and clerical jobs—occupations which have experienced many changes,including reductions, due to electronic switching, office automation, and related technologies.

Occupational trends

The technologies discussed in this bulletin will continue to alter the mix of occupations and skills required to provide communication services. A look at the employment prospects for several major occupations involved in installing, operating, and maintaining the Nation's telephone communications system provides insight into the impact of new technology.

Within the broad occupational group installers and repairers, the number of telephone and cable TV installers and repairers is projected by the BLS to decline by over 20 percent between 1988 and 2000, from 91,150 to 72,920.[9] Technologies which lower labor requirements for installers and repairers include modular, pre-assembled equipment which can be repaired more rapidly and with less labor; customer purchase and plug-in of telephone sets which eliminate labor requirements traditionally borne by the telephone companies; further growth in the proportion of buried cable, which requires less maintenance; and more widespread use of cables with "quick connect" features, which speed repairs. Moreover, the widespread use of fiber optic cables and related technology requires new installation and repair skills and proficiency with new types of tools.



Credit card telephones eliminate change and coin box operations, but require new servicing skills.

Central office and PBX installers and repairers are a second major occupational group affected by new technology, and the number of workers in this occupational group is expected to decline by about 20 percent by 2000 from 72,500 in 1988 to 57,580.

[9] BLS projections for industry employment in 2000 are based on three alternative versions of economic growth—low, moderate, and high. For details on assumptions and methodologies used to develop these projections, see the *Monthly Labor Review*, November, 1989.

Digital switching systems incorporate modular designs and self–maintenance features that reduce labor requirements for installers and repairers. Less wiring and soldering are needed in installation and repair tasks, equipment increasingly is being replaced rather than repaired, and computers are being used to pinpoint problems and outline repair steps—a combination of developments that modify skill and labor requirements for thousands of workers.

Telephone operators have been steadily affected by changes in technology over several decades, and further diffusion of more complex automated systems including electronic switching systems, automatic directory assistance systems, and related computer–based innovations are lowering labor requirements. The number of operators is projected by the BLS to decline by over 14 percent by 2000, from 83,320 in 1988 to 71,230. Telephone operators will need to acquire proficiency in operating the automated systems, and be able to retain and recall technical information related to these systems.

General office clerks is a major occupational group for which employment is projected to grow by about 12 percent, from 60,160 in 1988 to 67,610 in 2000. Files and other office records increasingly are being stored in electronic data bases, and clerical workers in modern offices use personal computers, printers, plotters, FAX, microfiche, and related equipment to carry out work tasks. Consequently, clerks in these offices often perform functions related to data entry.

The number of managers and administrators is expected to grow about 18 percent, even though computerized data bases, word processing, computer networking, teleconferencing, and related innovations continue to increase productivity. There were 63,650 managers and administrators in 1988. The projection for 2000 is 75,090. The increase in the demand for managers is related to the growing number of services provided through the telephone network and to the many small service and specialty firms that are appearing within this industry. The increase in competition also requires new forms of management and administration. Skill in the use of personal computers and software packages is an important job requirement, and training programs to enhance proficiency in these tasks are being made available to managers and administrators. People entering these professions must be computer literate and aware of the roles of workstations, networks, systems analysis, and other computer–related activity.

Technological change in the telephone communications industry also has led to significant employment expansion in other key occupations. As an example, the number of computer systems analysts is projected to increase nearly 50 percent as diffusion of computer systems continues over the next decade. The 7,900 computer systems analysts that the BLS projects will be working in the industry in 2000 will be involved in major projects related to the extension of automation, including systems that "speak" a common digital language.

Table 2. Employment trends in telephone communications, selected periods 1967–88 and projected 1988–2000

Period	Average annual percent change[1]
All employees	
1967 – 88	0.4
1967 – 73	3.6
1973 – 79	.6
1979 – 88	-2.4
1988 – 2000 projection (moderate)[2]	.2
Nonsupervisory workers	
1967 – 88	.1
1967 – 73	3.4
1973 – 79	– .4
1979 – 88	-2.3
Women workers	
1967 – 88	– .2
1967 – 73	1.9
1973 – 79	.8
1979 – 88	-2.9

[1] Least squares trend method for historical data, compound interest method for projection.
[2] BLS makes low, moderate and high growth projections.
Source: Bureau of Labor Statistics

Adjustment of Workers to Technological Change

Deregulation and technological changes have had a major impact on employment, the structure of occupations, and skill requirements. Programs to protect employees from the adverse effects of these and related changes, and to assist them to function in a more automated work environment, are incorporated into union contracts and in special, innovative arrangements between labor and management.

In the telephone communications industry, approximately 55 percent of the work force is covered under provisions of formal labor–management contracts. Most nonsupervisory employees are union members. The Communications Workers of America (AFL–CIO) is the largest union in the industry and covers by far the greatest number of employees. Substantially fewer employees are members of smaller unions, both independent and AFL–CIO affiliated.

General provisions of labor contracts are helpful in mitigating the adverse impact of technological and other changes. These include the use of seniority in layoff and recall, providing advance notice of layoffs, the use of part–time workers during slack periods, arranging training to meet new skill demands, profit sharing, and making available severance pay when displacement is unavoidable.

Some contract provisions in labor agreements directly address the issue of technological change. An example of an innovative and cooperative approach to facilitate adjustment to change is the joint union–management Technological Change Committee provided for in one of the union contracts.[10] The purpose of the committee is to identify and to discuss issues related to innovations that are likely to affect union members. The agreement provides for discussing pending innovations, including 6 months advance notice prior to their introduction, exploring alternative employment arrangements for employees, and addressing related topics as part of the committee agenda.

Retraining employees affected by new technology also is receiving increased attention. As a general observation, employees in the telephone communications industry will need to become more computer literate, flexible, and broadly knowledgeable about the system. For example, telephone operators will need a good basic educational background and some knowledge of computer operations.

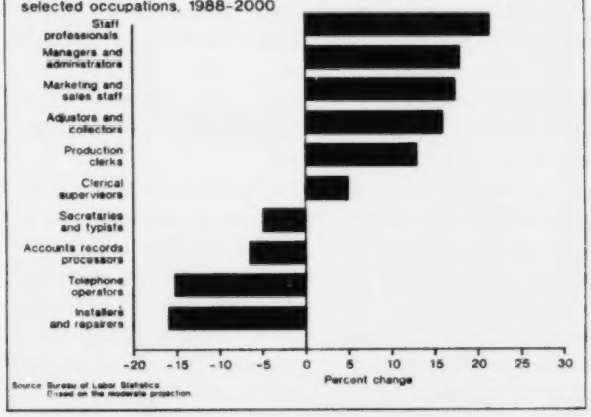
The importance of training as a mechanism for adjustment to change is recognized in collective bargaining agreements.[11] Under provisions of one major agreement, a Training Advisory Board consisting of management and union representatives was formed to assess training requirements, identify problems created by major technological and organizational changes, develop programs to assist displaced employees, and undertake related measures.

Managers and administrators also will need to be knowledgeable on broad issues related to the fast pace of change in communications technology. Special courses and programs at universities and private companies are available to inform managers and administrators about the implications of regulatory changes, the availability and capability of evolving technologies, and their potential impact for corporate strategy, markets, human resources, and related topics. Technical courses on how to install, operate, and maintain fiber optic networks, electronic switching systems, and other advanced technologies also are increasingly available to promote diffusion and to assist craft workers and others to adjust to new job demands.

The impact of technology on skills in the telephone communications industry is difficult to measure and assess precisely. Automation can change a job in various ways. For example, some new duties of telephone operators require more knowledge and more complex tasks. Other duties are simpler, because call responses are provided by automated systems. Workers bear new responsiblity for communication equipment technology.

The consequences of equipment malfunction and downtime must be considered. In many industries studied by BLS, change is less disruptive when training programs and techniques that promote employment security are in place.

Chart 3. Outlook for telephone communications employment in selected occupations, 1988-2000



Source: Bureau of Labor Statistics
Based on the moderate projection

[10] Agreement between Local 827, International Brotherhood of Electrical Workers, AFL–CIO, and New Jersey Bell Telephone Company, Plant and Engineering Departments, August 10, 1986.

[11] Agreement between Pacific Bell and Nevada Bell and the Communications Workers of America, August 3, 1986.

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BLS publications on technological change

The BLS publications listed below are available for reference at many public and school libraries and at Government depository libraries. Publications marked with an asterisk (*) also are available on microfiche and in paper copy from the National Technical Information Service, U.S. Department of Commerce, 5282 Port Royal Road, Springfield, VA 22161.

Trends in Manufacturing: A Chartbook (Bulletin 2219, 1985), 104 pp.

Portrays long-term trends in manufacturing output, employment, productivity, and related economic indicators and presents some international data for comparison. It places special emphasis on the 1973–83 period.

*Technology, Productivity, and Labor in the Bituminous Coal Industry, 1950–79** (Bulletin 2072, 1981), 69 pp.

Chartbook with tables and text; appraises some of the major structural and technological changes in the bituminous coal industry and their impact on labor.

The following BLS publications appraise the major technological changes emerging in the covered industries and discuss their current and potential impact on productivity, employment, and occupations.

Technological Change and Its Labor Impact in Four Industries (Bulletin 2316, 1988), 42 pp.
(Contract construction, railroad transportation, air transportation, and petroleum pipeline transportation)

Technology and Its Impact on Labor in Four Industries (Bulletin 2263, 1986), 47 pp.
(Lumber and wood products, footwear, hydraulic cement, and wholesale trade)

Technology and Its Impact on Labor in Four Industries (Bulletin 2242, 1986), 46 pp.
(Tires, aluminum, aerospace, and banking)

The Impact of Technology on Labor in Four Industries (Bulletin 2228, 1985), 49 pp.
(Textiles, paper and paperboard, steel, and motor vehicles)

Technological Change and Its Labor Impact in Four Industries (Bulletin 2182, 1984), 44 pp.
(Hosiery, folding paperboard boxes, metal cans, and laundry and cleaning)

The Impact of Technology on Labor in Five Industries (Bulletin 2137, 1982), 60 pp.
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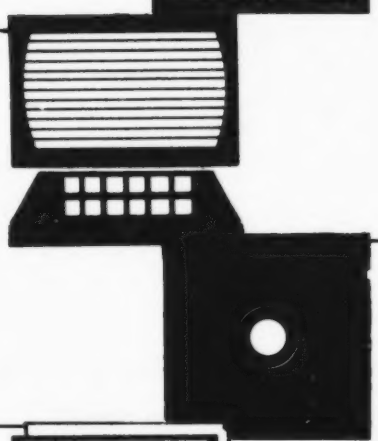

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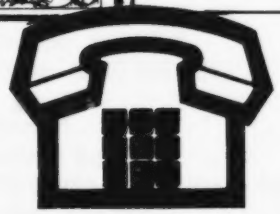
Monthly Labor Review:

Occasional articles discuss the full range of BLS productivity findings. Tables present up-to-date measures in every issue. Subscription available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $20 a year; $5 single copy.



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